Validation of Fitness for Duty Standards Using Pre- and Post-flight Capsule Egress and Suited Functional Performance Tasks in Simulated Reduced Gravity: Pilot Egress Fitness Study

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Science Background

- Both physiological adaptation to microgravity and re-entry into a gravity environment result in reduced functional capacity
- Quantification of astronauts' post-landing functional performance is necessary to design concepts of operation for exploration missions.
- There are two high-risk tasks that may have to be performed soon after gravity transitions:
  - Unassisted capsule egress task after return to Earth
  - Planetary EVA soon after landing on Mars (or the Moon)

Objectives

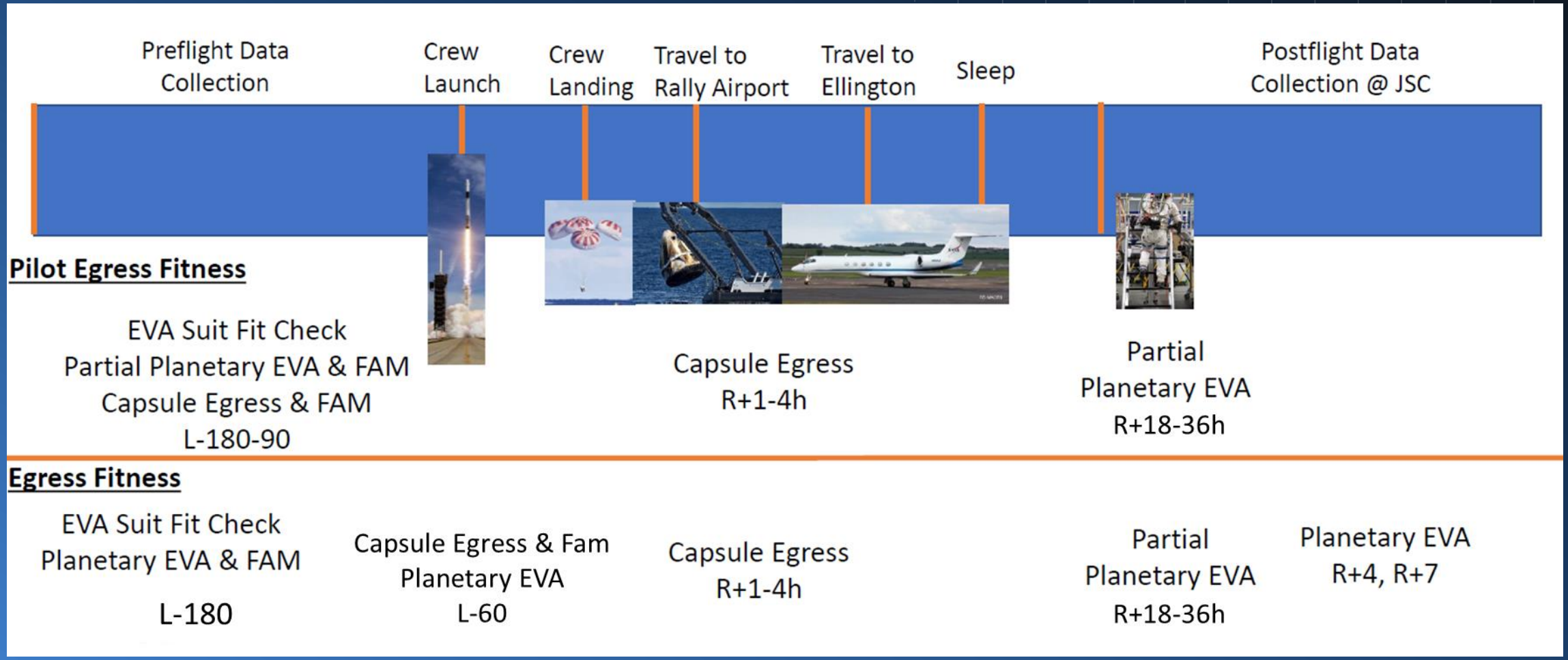
Egress Fitness Study

1. To quantify post-landing time course changes in unassisted capsule egress and planetary EVA task performance
2. To characterize the recovery to acceptable planetary EVA task performance as a function of EVA task type, time in space, time post-landing, and other potential determinants of performance (e.g., sleep, nutrition, exercise, sensorimotor performance)
   - Requires data sharing with other CIPHER studies and MedB testing

Pilot Egress Fitness

1. To determine the feasibility of performing these tasks and establish a precedent for doing so at different landing sites
   - SpaceX, Boeing, Soyuz landings are all possibilities

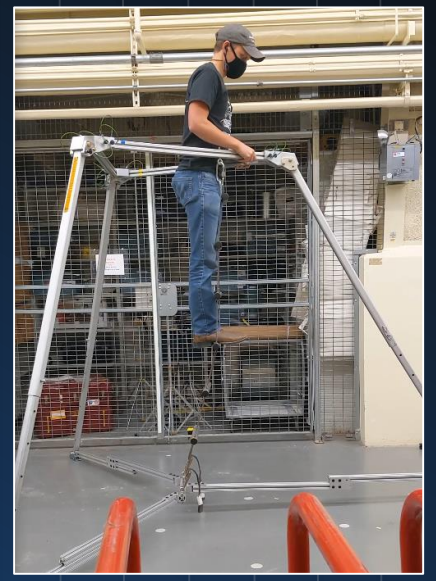
Experiment Design Review

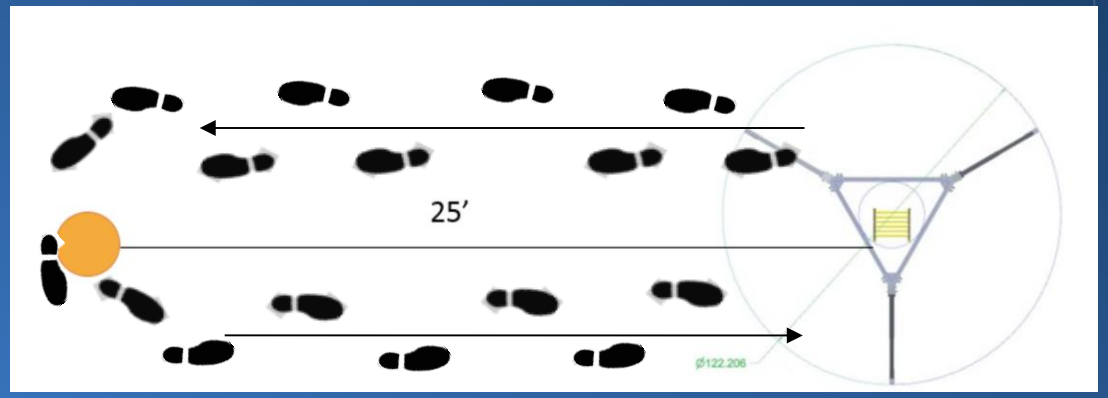


Unassisted Mock-up Capsule Egress

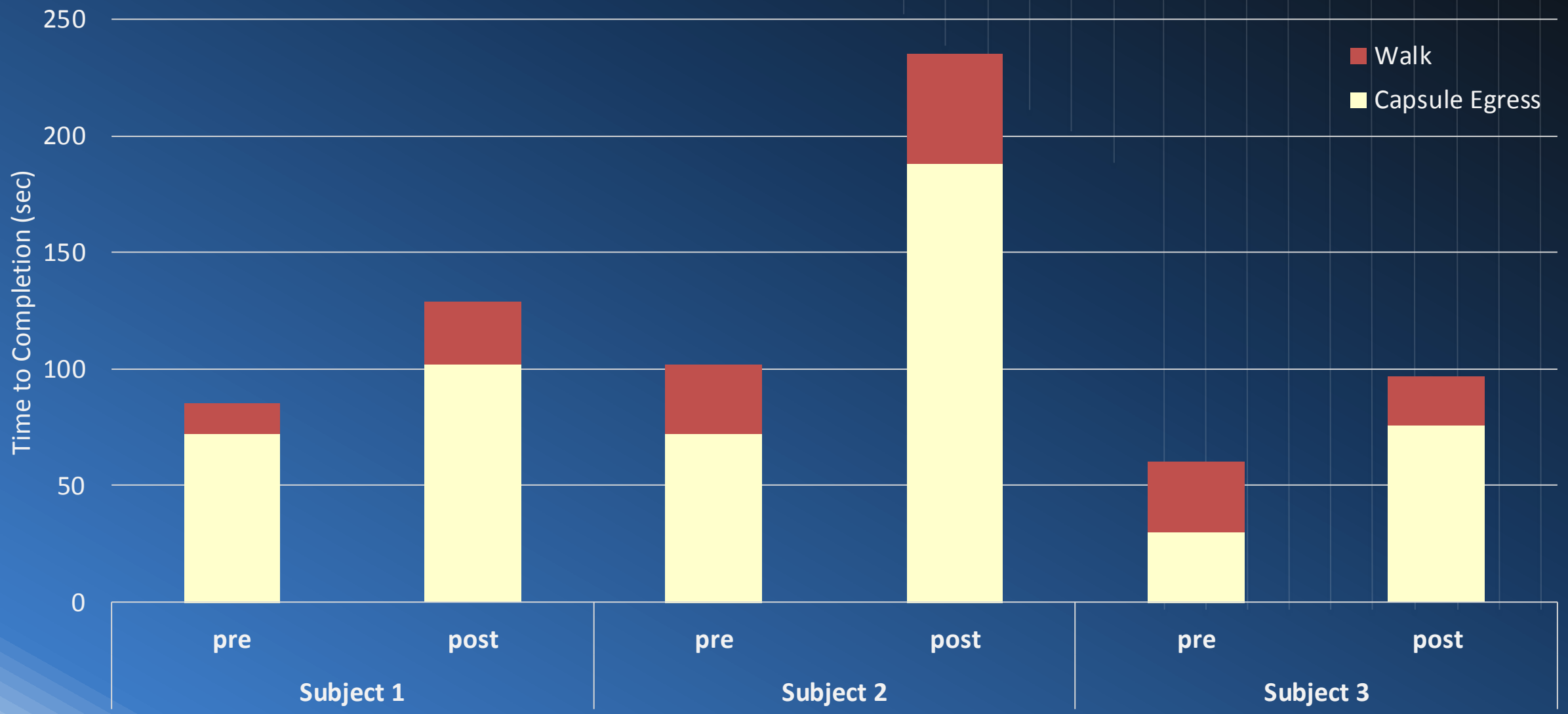
Capsule egress test is performed pre- and post-flight (R+0 at rally airport) using a capsule simulator (before doffing the LEA suit**):

1. Egress from “recumbent seat” (lying on your back)
2. Deploy and secure ladder
3. Ascend the ladder with survival pack
4. Hand survival pack out of the top of the hatch to operator
5. Descend ladder
6. Retrieve survival pack and walk to a safe waypoint (medical tent or around cone ~50ft)
7. Self-doff LEA suit (**not performed at SpaceX landings)





Mock-up Capsule Egress Results



Partial Planetary Simulated EVA

Pre-flight: Anytime pre-flight (with fam) after Mark III or xEMU Suit Fit Check
Post-flight: R+1 at JSC

- Planetary EVA circuit consists of functional tasks that represent a realistic post-landing EVA scenario
- Tested at JSC in the Active Response Gravity Offload System (ARGOS) offloaded to Martian gravity - 3/8 G
- Performed in MKIII or xEMU suit @ 4.3 psid
- Task evaluation includes:
  - Ability to complete the task
  - Time to completion
  - Metabolic energy expenditure
  - Heart rate
  - Video

Partial Planetary EVA Tasks

1. Pre-test brief, LCG Don, EIS/Suit Exposure
2. “Self” ingress and pressurize EVA suit
3. ARGOS calibration & float to top of lander*
4. Translate through a hatch
5. Descend a ladder
6. Supply umbilicals task board
7. Perform object relocation
8. Align with rear entry port sim
9. “Self” egress EVA suit

- *Ladder ascent planned for CIPHER
  - Originally to be done at start
  - Planning to move towards the end after rear entry port

Partial Planetary EVA Results and Lesson Learned

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- These tasks offer limited data other than yes/no but are necessary
- Goal of these tasks is to minimize overall time while maintaining overall test objectives
- "Self" don/doff is limited because these suits were not designed for it
  - Ingress/Don – Includes changing into LCG/biomed/accessory clothing climbing up ladder, mating LCG, donning suit with gloves on, throwing shoulder straps back
  - Egress/Doff – includes pushing out of sui, demating LCG, climbing down ladder, LCG/biomed/accessory removal
- Having a changing tent right next to ARGOS is required to stay within time limits

Partial Planetary EVA Results and Lesson Learned

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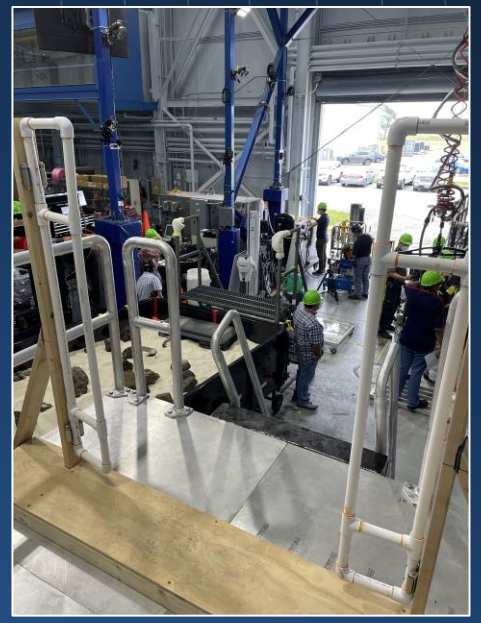
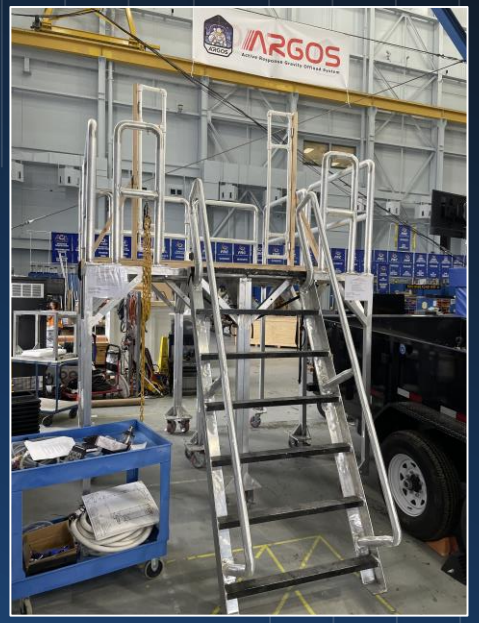
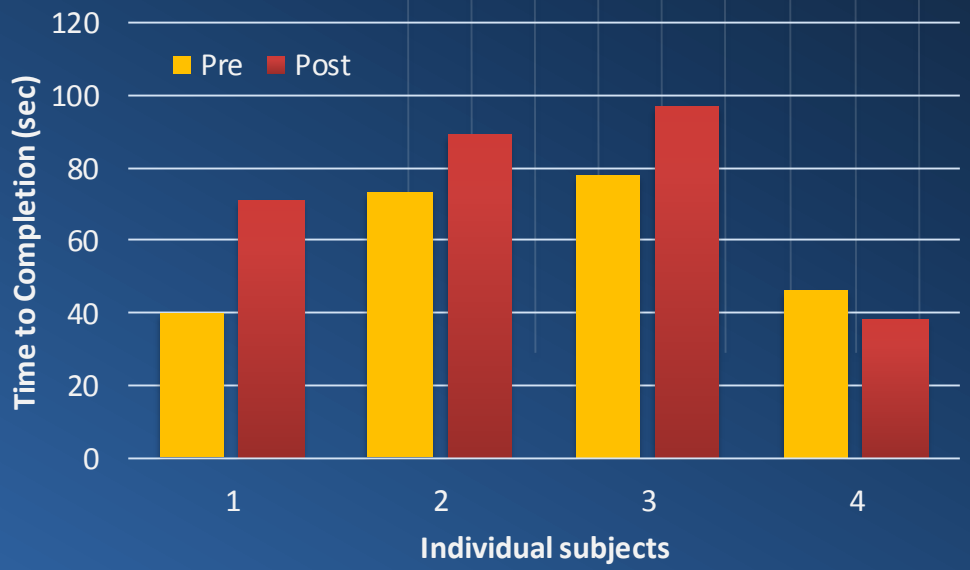




- First test was very hands-on in terms of support and spotting of the test subject (R+18 hours)
- Extra spotters alongside subject during testing were welcomed by the crew, but we had to instruct spotters to not automatically assist, rather only to intervene if asked by subject/test team or if the subject was in danger



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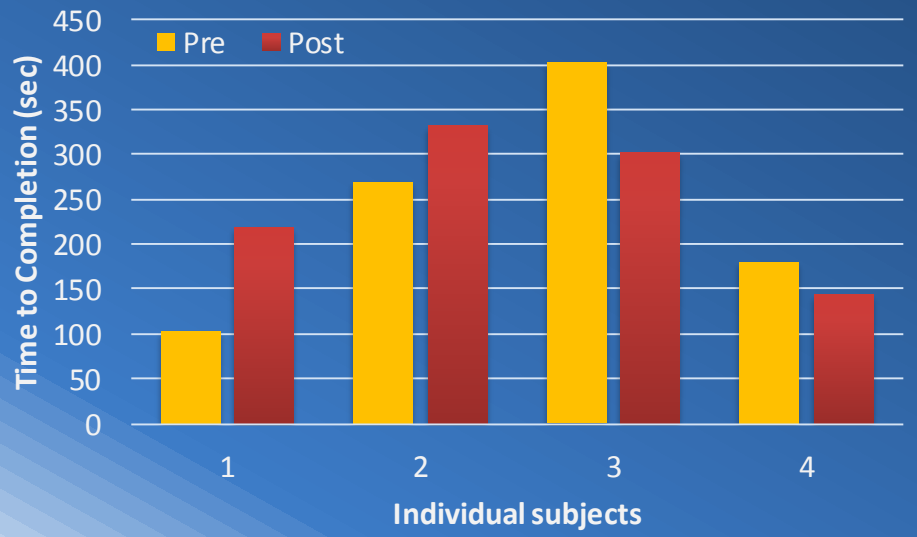
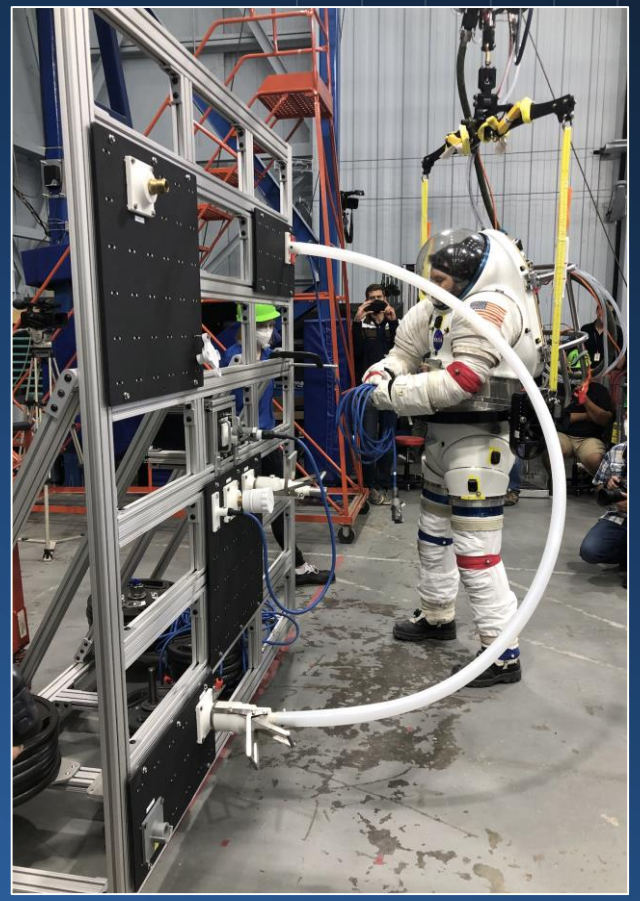


Initial Pilot Config



Current CIPHER Config

- Instructions: have reduced operational fidelity in favor of simplicity (no FOD checks – just mate the connectors)
- Layout: reorganized to minimize unnecessary interference between tasks

Partial Planetary EVA Results and Lesson Learned

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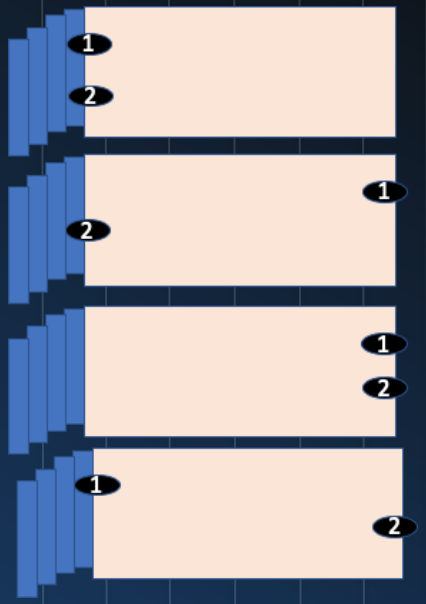
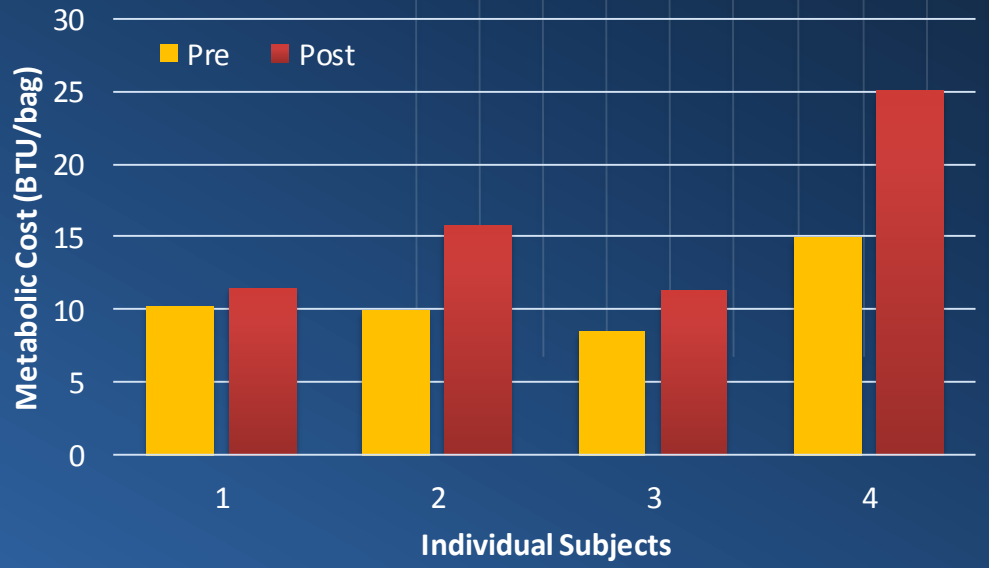


- Total metabolic cost to move each bag increased for all subjects
  - Average metabolic rate was similar pre vs post
  - All subjects moved less bags post
  - All subjects took longer to complete each transfer post
- Task updates – document a consistent approach to laying out the rocks for the start of the task



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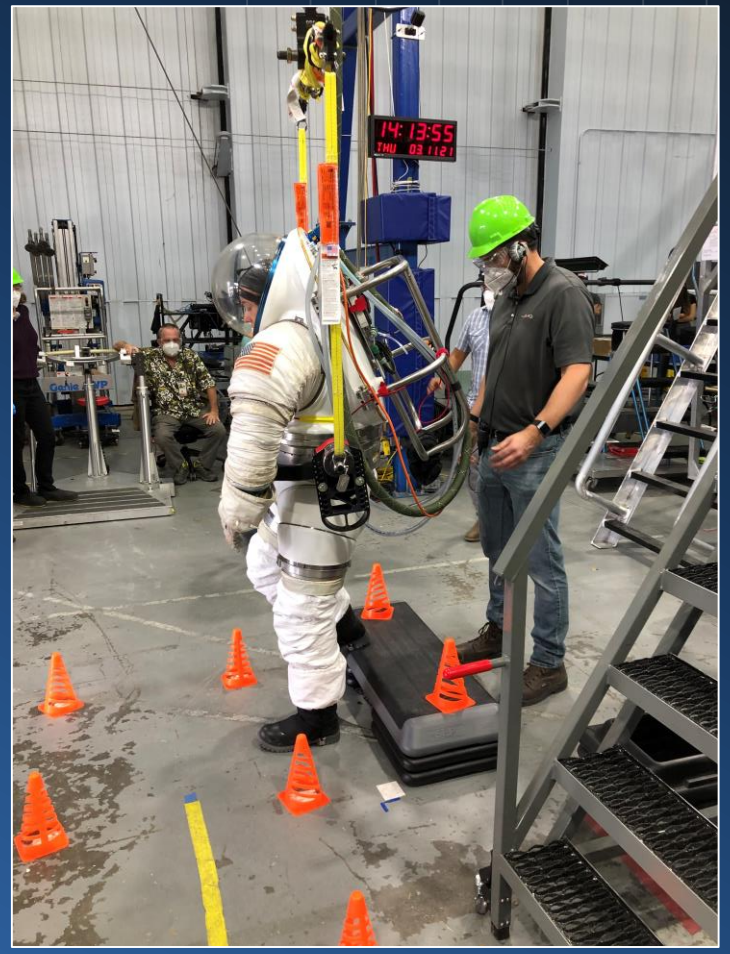
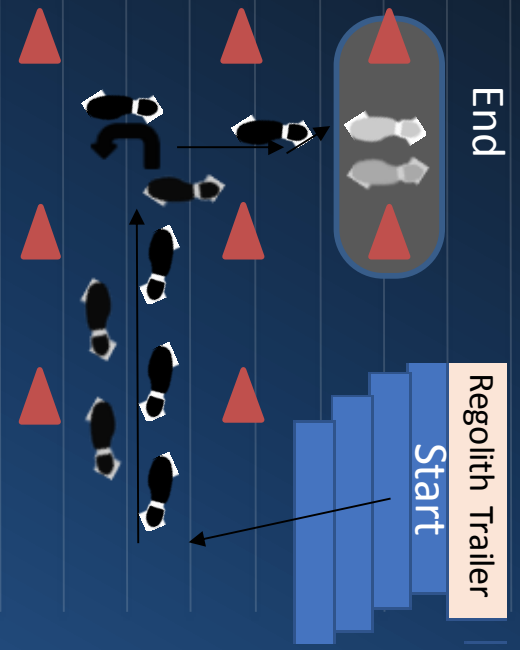




- All subjects completed task
- Short duration limits data to yes/no for task completion
- Task Updates – add alignment guides/targets now that gimbal and mock PLSS configuration is selected

Pilot vs CIPHER Egress Fitness Task & Timeline

Step	Task	Time (Pilot)	Time (CIPHER)
1	Subject familiarization (FAM session only)	10*	10*
2	Prep for space suit activities (Don LCG/bio)		
3	Don and pressurize space suit	15	15
4	ARGOS integration		
5	Walk with or without assistance		2
6	Ladder ascent**		2
7	Hatch ops	2	2
8	Ladder descent	2	2
9	Supply umbilicals task board	5	5
10	Object relocation	5	5
11	Geology tasks		15
12	Incline/decline ambulation		25
13	Rear entry port simulator	2	2
14	ARGOS de-integration, depressurization		
15	Self Doff suit	10	10
	Total Time	39 (49) min	85 (95) min

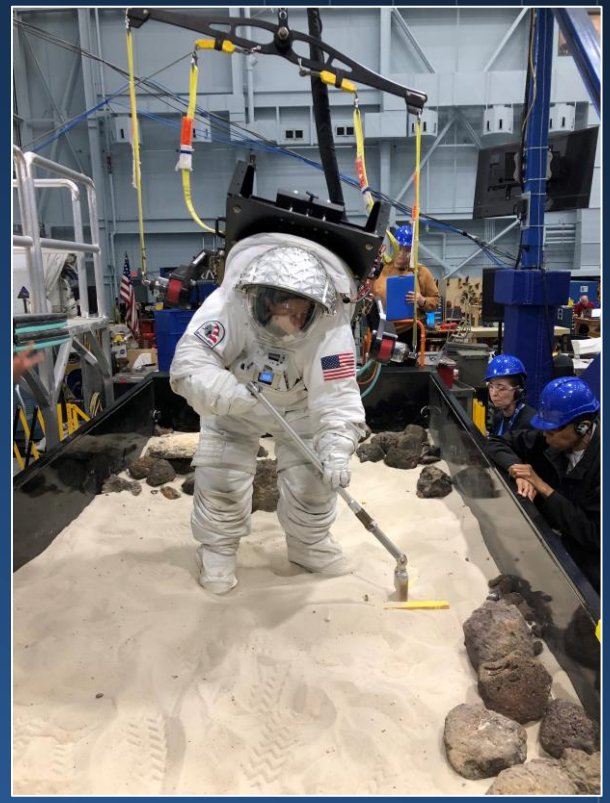
Pilot & CIPHER

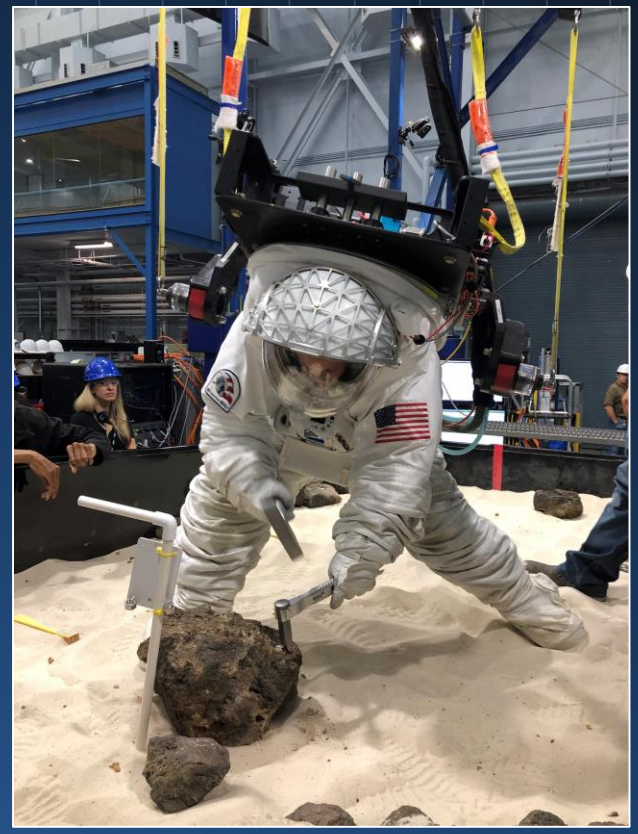
CIPHER Only

** Plan is to move this to right after step 13

Unique CIPHER Egress Fitness Tasks: Geology Task

- Mock X-ray Fluorescence (XRF) sample (1 min kneeling static hold)
  - Identify large rock sample & complete 1 minute static hold while kneeling to obtain XRF sample
- Kneeling rock chip sample on the same rock using the hammer & chisel
- Standing trenching sample using scoop/shovel with an extender handle
- For each of the samples, place a sample marker, take a photo, and take a sample and store in a sample bag.
  - Each sample will take roughly 5 min





Unique CIPHER Egress Fitness Tasks: Incline/Decline Ambulation

Treadmill Grade	Distance (m)	*Speed (mph)	*Distance (Cumulative miles)
0	50	Start 1.5 mph	0.03
-5	100	Self select	0.1
0	50		0.13
5	100		0.2
0	50		0.23
-10	100		0.3
0	50		0.33
10	100		0.4
0	50		0.43
20	100		0.5

*Originally distance was planned in meters, but treadmill only operates in mph and miles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THANK YOU !
ANY QUESTIONS?
NASA